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Feyissa, Aberham Hailu; Christensen, Martin Gram; Pedersen, Søren Juhl; Hickman, Minka; Risum, Jørgen; Adler-Nissen, Jens

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Investigating fluid to food particle heat transfer in a laboratory scale half-vessel through video-recording and modelling

Author(s): Dr. Aberham H. Feyissa, PhD., Mr. Martin G. Christensen, M.S., Mr. Søren J. Pedersen, M.S., Ms. Minka Hickman, M.S., Mr. Jørgen Risum & Professor Jens Adler-Nissen, PhD.

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This paper concerns particles heated in a liquid food in situations where the Biot-number is above 0.1. The main aim of the paper is to develop an experimental setup and to utilize mathematical-physical models of heat transfer for studying the heat transfer and penetration into model food particles. The laboratory setup was constructed as follows: A cast iron pot was cut in half along the vertical symmetry plane and a glass plate was glued onto the open half with a temperature-tolerant adhesive. This formed a window that allowed visual inspection of the boiling processes and physical changes in the food. The idea is inspired by Myhrwold et al. (2011). The vessel was heated by placing it on a contact frying rig where the contact temperature can be controlled, and the temperature of the fluid and evaporative mass loss is measured continuously (Ashokkumar and Adler-Nissen, 2011).

As model food particle a potato cut in half was tightly attached to the glass plate and submerged in the liquid. The process was filmed with a video camera, and a moving gelatinisation front was observed in the potato. To confirm that this phenomenon was gelatinisation, cut surfaces were coloured with iodine, and the coloured front resembled the front seen by the video inspection. Furthermore, T-type thermocouples were attached inside the half potato to investigate the actual gelatinisation temperature. This enabled the construction of a heating curve inside the potato serving as a validation tool for modelling work. To investigate the effect of different heat transfer conditions for the potato, experiments were conducted with water and a tomato soup as the liquid medium. The half potato heated in water gave a symmetrical heating profile (gelatinisation front) whereas the one heated in the soup gave unsymmetrical heating profile. The results clearly showed the effect of liquid rheology on the heat transfer conditions – the effect of convection heat transfer and boiling induced steam.

A mathematical model was developed which describes coupled heat and fluid flow where the partial differential equations were solved using COMSOL Multiphysics®3.5. The model was utilized to predict the temperature inside the spherical particle during heating, where this prediction was compared with the obtained experimental temperature profile. The evaluation of the model and the experimentel setup will serve as a tool for understanding the heating different types, sizes and shapes of particles in various liquid media.

References
Myhrvold, N., Young, C. and Bilet, M. (2011) Modernist Cuisine: The art and science of cooking. The cooking lab; Spi Har/Pa edition, Bellevue, WA 98005, USA

Audio/Visual:

Topic(s): Multi-scale/Multi-phase modeling to develop food processing technologies; Innovations in conventional thermal processing; Advances in Food Dehydration/Frying

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